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ORIGINAL STUDY

Two methods of atlantoaxial stabilisation for atlantoaxial instability

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Thirty-seven patients, 19 males and 18 females, with a mean age of 37.6 years (range 9-62), underwent atlantoaxial fusion for atlantoaxial instability associated with pseudarthrosis of the odontoid, fixed rotary subluxation, rheumatoid arthritis, and mongolism. Two operative techniques were used : transarticular C1-C2 screws and posterior bone grafts according to Magerl, but without posterior wiring, in 24 patients (group 1), and C1 lateral mass screws/C2 pedicle screws, plates and posterior bone grafts, according to Goel, in 13 patients (group 2). The mean follow-up period was 27.6 months. In both groups 92% of the patients were free of neck pain. In group 1, 4 out of 9 patients with neurological involvement improved one Frankel grade and in group 2, 3 out of 5. The fusion rates were 96% and 100%, respectively ; they were superior to the rates mainly seen after a Gallie fusion : 67 to 86%. One vertebral artery injury without sequelae occurred in group 1, and one wound infection, that healed with debridement, in group 2. In conclusion, the results were excellent in both groups, but slightly better in group 2.

Keywords : atlantoaxial ; instability ; upper cervical spine ; transarticular screws ; lateral mass screws ; pedicular screws ; fusion.

INTRODUCTION

Atlantoaxial instability is induced by various causes and can result in serious complications if not treated properly. Common causes include trauma, rheumatoid arthritis, and congenital dysplasia of the dens (*1,9*). Atlantoaxial stability is maintained by the normal binding ligaments of C1 and C2, the transverse ligament, the odontoid process and the lateral joints (*22*). If any of these structures are damaged or defective, stability can no longer be maintained (*20,22*).

Various techniques of atlantoaxial stabilisation have been described in the literature. Gallie in 1939 (*6*) reported atlantoaxial arthrodesis by posterior wiring and autologous grafting. Magerl and Seeman (*14*) introduced the C1-C2 transarticular screw fixation (fig 1). However, this technique is technically demanding and requires precise radiological and intraoperative knowledge of the localization of the vertebral artery to minimize the risk

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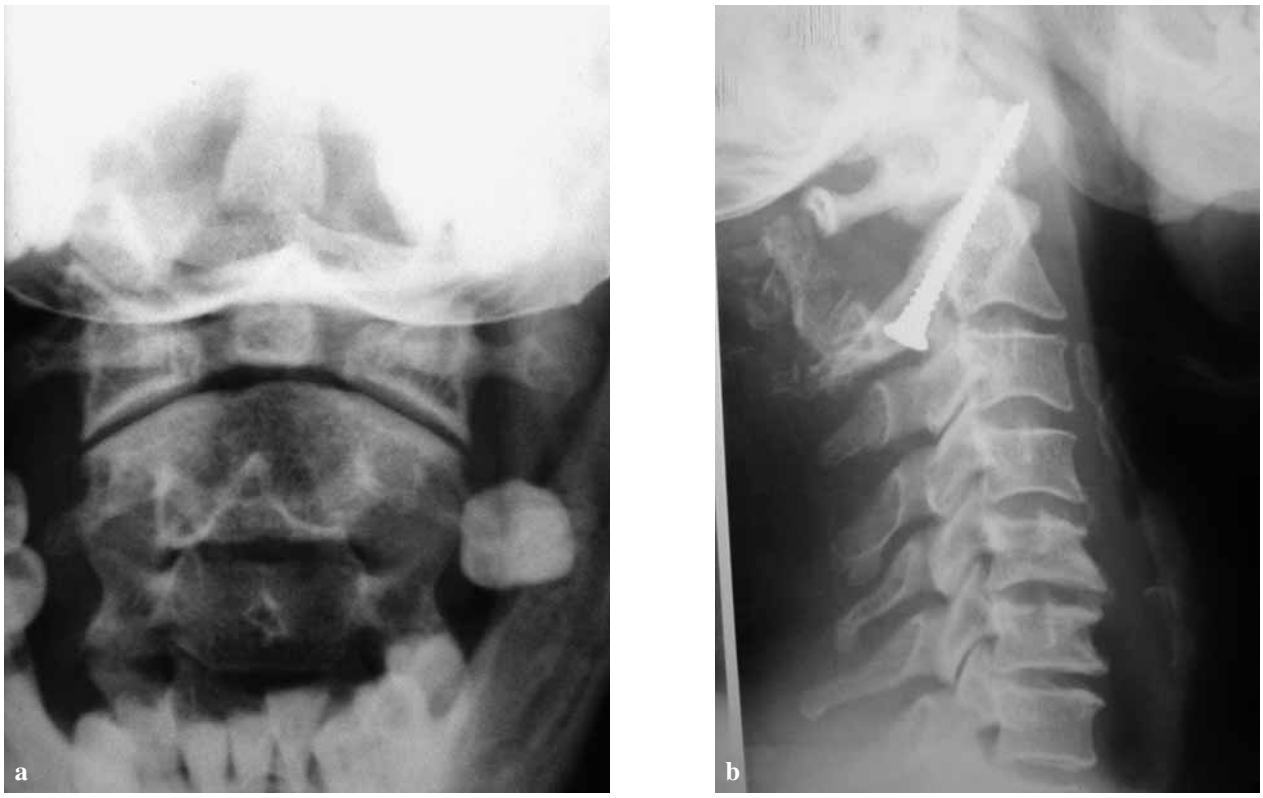

Fig. 1. — a. Open mouth A-P view showing pseudarthrosis of the odontoid ; b. Lateral view showing the transarticular screws (Magerl technique).

of iatrogenic damage. Goel *et al* (*7*) described the C1 lateral mass screws/C2 pedicle screws and plates technique (fig 2). They too reported that the procedure is technically demanding and that an exact three-dimensional understanding of the anatomy of the region and of the vertebral artery is mandatory.

The aim of this study was to compare the techniques of Magerl and Goel in patients with atlantoaxial instability.

MATERIALS AND METHODS

Thirty-seven patients with atlantoaxial instability, operated upon in the period 2002-2004, were retrospectively evaluated. Twenty-four of these (group 1, Magerl) underwent the Magerl operation : transarticular screw fixation C1-C2, but without the additional posterior wiring described by Magerl. Thirteen other patients (group 2) underwent the Goel technique.

In group 1 (Magerl, n = 24) there were 13 males and 11 females. The mean age at the time of surgery was 38.6 years (range 11-62). The instability was due to pseudarthrosis of the odontoid in 17 patients, to rheumatoid arthritis in 5 and to mongolism in 2 patients. The presenting symptoms included neck pain in all 24 patients, occipital headache in 15 patients, and dysphagia in one patient. Fifteen patients were neurologically intact while 9 patients showed a neurological deficit at the time of presentation (table I). The mean follow-up period was 30.2 months (range 26-40 months).

In group 2 (Goel) (n = 13) there were 6 males and 7 females. The mean age at the time of surgery was 36.4 years (range 9-57 years). The instability was due to fixed rotary subluxation in 6 patients, pseudarthrosis of the odontoid in 3, rheumatoid arthritis in 2, and mongolism in 2 patients. The presenting symptoms were neck pain in all 13 patients, occipital headache in 9 patients, and torticollis in 4 patients. Eight patients were neurologically intact while 5 showed a neurological deficit at the time of presentation (table I). The mean

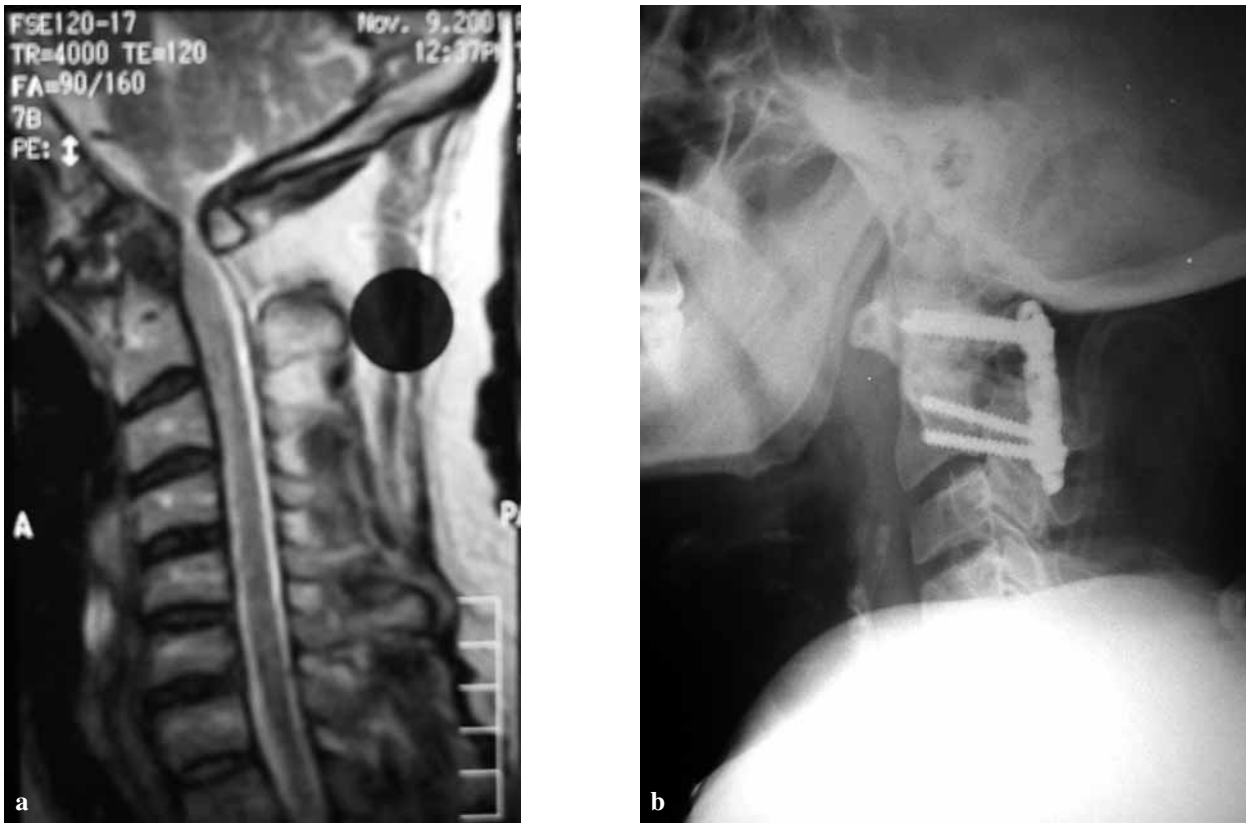

Fig. 2. — a. Sagittal MRI-scan showing circumferential cord compression C1-C2 in a patient with rheumatoid arthritis ; b. Post-operative lateral radiograph showing the C1 lateral mass screws/C2 pedicle screw plate technique (Goel) with complete reduction of the atlantoaxial articulation.

follow-up period was 25.1 months (range 24-28 months).

Preoperative assessment

Plain radiographs of the cervical spine (antero-posterior, lateral, open mouth, and flexion-extension views) were obtained in all patients. Tomograms were added in 9 patients, a CT-scan in 20, and an MRI-scan in all 37. The neurological status of the patients was assessed according to the Frankel *(6)* scale (table I).

Operative technique

General anaesthesia with endotracheal intubation was the rule. Skull traction was applied in the supine position. Patients were then carefully rolled into the prone position. Gentle manipulation of the neck through the traction device was used under fluoroscopic control in an attempt to obtain reduction. Occasionally, if reduction was not completed by closed means, it was obtained intraoperatively by manipulating the C1 posterior arch, the C2 spinous process or the C1-C2 joint.

The posterior elements of the vertebrae C1-C4 were freed by subperiosteal dissection through a standard posterior midline approach. In 24 patients (group 1) transarticular C1-C2 screws were inserted bilaterally, according to the Magerl *(14)* technique ; autologous grafts were added, however without posterior wiring, unlike the original technique. In 13 patients (group 2) posterior C1 lateral mass screws, C2 pedicle screws, and plates were used following the Goel technique (*7*) ; but a more superior entry point for the C1 screw was used, so clearing the space for the C2 root. As in Group 1, autologous morselized bone grafts were obtained from the posterior iliac crest, and applied to the C1-C2 area after decortication. Finally, the wound was closed in layers over a subcutaneous drain.

Table I. — Preoperative and postoperative neurological grading

Frankel grade	Group 1 Preoperative (n = 24)	Group 1 Postoperative (n = 24)	Group 2 Preoperative (n = 13)	Group 2 Postoperative (n = 13)
Frankel E	15	16	8	8
Frankel D	3	4	2	4
Frankel C	4	3	2	1
Frankel B	2	1	1	None
Frankel A	None	None	None	None

Postoperative management

All patients had prophylactic antibiotic cover for 24 h. The drains were removed after 48 h. All patients were mobilised in a Philadelphia collar. They were routinely discharged one week postoperatively, and reassessed in the clinic at 6 weeks, 3 months, 6 months and 12 months with anteroposterior, lateral, and open mouth radiographs.

RESULTS

Group 1 (Magerl technique)

Twenty-two out of 24 patients (92%) were pain free, while 2 patients had residual neck pain, aggravated by neck movement, but improving with a cervical collar. The patient with dysphagia (believed to be due to bulbar compression) improved in the immediate postoperative period. Four out of 9 patients (44%) with a preoperative neurological deficit improved one Frankel grade (table I). The overall fusion rate in Group 1 (n = 24) was 96% as 23 patients out of 24 patients showed a definite bridging fusion mass on radiographs. Only one patient showed an incomplete fusion mass ; flexion and extension views were normal, and this was considered as a stable fibrous union. One patient had severe bleeding during the drilling of the second transarticular screw hole ; it was presumed to be due to a vertebral artery injury. This was promptly controlled by the application of the screw. Postoperatively the patient had no neurological deficit and he was asymptomatic at final follow-up. Dural tears or neurological complications were not seen.

Group 2 (Goel technique)

Twelve out of 13 patients (92%) were pain free, while a single patient had some residual neck pain. The torticollis resolved in all 4 patients. Three out of 5 patients (60%) with a neurological deficit improved one Frankel grade (table I). A bridging fusion mass was seen radiographically in all patients. One patient developed an early infection that required surgical debridement, with a good result. There were no neurological problems or dural tears.

DISCUSSION

A recent cadaveric study (*18*) showed that the Magerl and the Goel technique were biomechanically equivalent, and superior to the classical wiring technique. This is probably the reason why the overall fusion rates with the Gallie posterior wiring technique vary from 67% to 86% (*3,19*), which is lower than the overall fusion rates reported for the Magerl and the Goel techniques : 98-100% for the Magerl technique (*10,13*), and 100% for the Goel technique (*7*). Moreover**,** the posterior wiring techniques necessitate halo-vest immobilisation.

The Magerl technique has been widely used. Most spine surgeons prefer to supplement the transarticular screws with a posterior cable-secured strut graft claiming superior mechanical stability (*12,16,17*). The overall fusion rate when using this technique has been reported to be in the range of 98-100% (*10,13*). However, Stillerman and Winston (*21*) and more recently Wang *et al* (*23*)

dropped the supplementary wiring and achieved an overall fusion rate of 95% and 100% respectively. The reported fusion rates in the current series (96% and 100%), also without posterior wiring, are similar to those reported in the literature ; indeed, there was only one fibrous union in group 1. Omitting wire reinforcement has the added advantage of avoiding neurological risk during the passage of the wire and tendency to backward displacement of the axis, further compromising the canal, particularly in those with posterior instability. Although fixation by transarticular screws leads to excellent fusion rates, it is technically demanding and has a potential risk of injury to the vertebral artery with an incidence from 3.7% (*3*) to 7.8% (*2*). One vertebral artery injury occurred in group 1 (Magerl) without neurological sequelae ; a postoperative CT-scan revealed that the screw was placed too laterally. Another disadvantage of the Magerl technique is the fact that the transarticular screws cannot be inserted in case of fixed subluxation C1-C2, aberrant vertebral artery, or thoracic hyperkyphosis.

These limitations have incited the authors to use the Goel technique, which can be used when there is incomplete reduction, all the more as the screws can be manipulated as joy sticks to reduce residual subluxation, in addition to the reduction effect of tightening the screws over the plates. But the Goel (*7*) procedure also has some disadvantages. In the original technique bilateral sacrifice of the C2 ganglia was advocated in order to prepare the atlantoaxial facet joints for arthrodesis. The authors chose a slightly more superior entry point for the C1 screw, which cleared the space for the C2 roots, so that they were preserved. Harms and Melcher (*11*) overcame this difficulty by using C1 screws with a proximal unthreaded part thus avoiding the C2 root. Goel *et al* (*8*) have highlighted the advantage of their method over other constructs. Biomechanical testing has shown that a C1 lateral mass screws / C2 pedicle screws and plates construct allows an average of 0.6 degrees more motion than do C1-C2 transarticular screws. In their opinion the plates act as a tension-band, providing stability in flexion/extension, and hence midline wiring as in the Gallie technique is not necessary. They reported a 100% fusion rate, almost without complications. Harms and Melcher (*11*) have used a modified Goel technique with polyaxial top loading screws and rods, without sacrificing the C2 ganglia, also with a 100% fusion rate. The technique has been shown to be biomechanically at least equivalent to the transarticular screws technique (*15*). Other authors have reported similar results (*4,5*). The current study also showed a 100% fusion rate.

In group 1, 4 out of 9 patients (44%) with a neurological deficit, and in group 2, 3 out of 5 (60%), improved one Frankel grade. Other authors have reported similarly high neurological recovery rates after surgical management of atlantoaxial instability (*22*).

CONCLUSION

Both the Magerl and the Goel technique lead to excellent fusion rates without any need for external immobilization. However, they are technically demanding and are not without risks. The neurological improvement is impressive. The authors believe that wiring, supplemental to bilateral transarticular screws, is not necessary.

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